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TECHNICAL MEMORANDUM

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Reviewed by:	Travis M. Gerber, PhD, PE Ryan Cole, PhD, PE, DGE
Date:	February 26, 2020
Job Number:	19-1225
Subject:	Jordan Valley Water Treatment Plant Upgrades

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Feb 26, 2020
STATE OF UTAH

INTRODUCTION AND BACKGROUND

We understand that Carollo Engineers (Carollo) has been retained by JVWCD (Owner) to provide design services for various upgrades at its water treatment plant, located at 15305 S 3200 W in Herriman, Utah. The project includes construction of a buried vault/box, the installation of a new 18-inch pipe, and concrete lining of two existing reclaim (formerly called backwash) ponds. The proposed pipe will run along the north side of the four (4) existing ponds in the northeast corner of the plant, generally paralleling an existing pipe, and be embedded along or just below the exterior side slope of the pond embankment fill.

Gerhart Cole (GC) has been retained to assist Carollo by providing geotechnical engineering support for this project. This technical memo (TM) summarizes findings from our field study and provides geotechnical design recommendations and construction considerations for project elements as described below.

- Updating seismic design parameters to be compliant with IBC 2018 (parameters developed for JVWCD's previous 12.5 MG Finished Water Reservoir project are for IBC 2012, and code has changed significantly since then).
- Providing earth pressures for design of a buried 20- x 12- x 10-foot deep vault/box.
- Providing recommendations for concrete lining for existing reclaim ponds.
- Assessing local slope stability associated with installation of new pipe along the north-facing slopes of affected the storage ponds.

SCOPE OF WORK

Our scope of work for this project is generally outlined in our proposal to Carollo, dated September 17, 2019 and can be summarized as follows:

- Field study consisting of 5 soil test holes.
- Geophysical survey to help evaluate seismic site classification.
- Laboratory testing.
- Geotechnical analyses and recommendations.
- Preparation of this technical memorandum.

FIELD STUDIES

Test Hole Drilling and Sampling

Five soil test holes, advanced to depths of about 17 to 30 feet, were completed between January 8 and 9, 2020. The test holes were advanced using a track mounted Fraste Multidrill XL rig and ODEX (downhole pneumatic percussion) drilling methods by ConeTec of Salt Lake City, Utah under the direction of GC. Test holes were positioned in the field to coincide with project elements, with input from Carollo and JVWTP personnel.

Subsurface conditions were logged by a GC field engineer at the time of drilling. Standard penetration testing (SPT) was performed using an automatic hammer. The energy efficiency of the hammer was reported to be approximately 79 percent. The number of hammer blows required to advance the sampler in 6-inch increments was recorded in the field, with the sum of the second and third 6-inch intervals constituting the SPT blowcount or "N-value." Bulk samples of drill cuttings were collected from test holes 19-TH-02, 19-TH-03, and 19-TH-05. Logs of the test holes are presented in Appendix A. Lines designating boundaries between different materials shown on the logs should be considered approximate; transitions between subsurface materials may be gradual or occur between sampling depths. In gravelly soils or when cobbles are present, SPT blowcounts may be higher than otherwise expected in less coarse soils of similar density or consistency. This occurs because the sampler tends to have increased resistance when trying to advance through/past larger clasts; the area of a clast may be significantly greater than that of the sampler, causing increased resistance and higher blowcounts.

Upon completion of drilling and sampling operations, the test holes were backfilled to the ground surface – test hole 19-TH-01 with soil cuttings and test holes 19-TH-02 through 19-TH-04, with cementitious, low-permeability grout. Test hole 19-TH-05 was finished with a two-inch diameter standpipe piezometer to permit measurement of ground water levels. The locations of the test holes, relative to project elements, is shown in Figure 1. Test hole coordinates (latitude and longitude) were recorded in the field with non-survey grade GPS equipment with approximate precision of 10 meters. Ground surface elevations were obtained from LiDAR data published on the Utah AGRC GIS portal website. Test hole summary data is presented in Table 1.

Geophysical Survey

In addition to the test holes, a geophysical survey was completed January 15, 2020. This survey consisted of both multichannel analysis of surface waves (MASW), and microtremor array measurements (MAM) was performed by Sage Earth Science under subcontract to GC using a 377-foot line and geophones spaced at 16.4-foot (5-meter) intervals. The results of the geophysical study, which presents a shear wave velocity profile for seismic site classification, are provided in Appendix C.

LAB TESTING

Laboratory testing was performed on select soil specimens obtained during the field study in order to further classify them and evaluate their engineering properties. Laboratory testing included index testing (particle-size distributions and natural moisture contents) on various samples, and one moisture-density relationship (i.e., "proctor compaction") test and one corresponding, one-point California bearing ratio (CBR) test on a bulk sample collected of soil cuttings from near the pond bottom elevation. Laboratory test results are tabulated in Table 2. Interpretive laboratory test results are included in Appendix B.

GEOLOGIC SETTING

The Salt Lake Valley is a sediment-filled basin flanked by two uplifted range blocks, the Wasatch Range and the Oquirrh Mountains. The Wasatch Range is the eastern boundary of the Basin and Range, a physiographic province characterized by a series of alternating generally north-south trending, normal-faulted, narrow mountain ranges and semi-arid to arid alluvial/pluvial valleys formed as a result of tectonic extension. At the foot of the Wasatch Range is the Wasatch Fault Zone (WFZ), which consist of multiple fault segments and poses a significant seismic hazard to the area.

During the late Pleistocene Epoch, the Salt Lake Valley and adjoining valleys were occupied by a succession of inter-basin lakes. Lake Bonneville was the last and probably largest of these massive lakes, with the post-ice age Great Salt Lake being its remnant. The presence of Lake Bonneville is observable by its shorelines, identified as several different "stands" or "benches" that ring the valleys on the mountain fronts. During Lake Bonneville, finer grained lacustrine materials were deposited within the lake with typically coarser alluvial and fluvial soils intruding from the margins. Lake Bonneville sediments bury many of the older sedimentary deposits in the valley (Lund, 1990).

The majority of Quaternary deposits (the Quaternary period being from approximately 1.8 million years ago until present) shown on surficial geology maps consist of sediments deposited or reworked by Lake Bonneville. Lake sediments include near-shore beach, delta, spit, and bar deposits. In deeper water toward the center of the valley, deposits consist of finer grained sand, silt and clay. Elsewhere, Holocene soils (post-Bonneville, about 10,000 years ago until present time) consisting of alluvium and flood plain deposits are located along the Jordan River and its tributaries, and extensive alluvial fans are located along mountain fronts.

SURFACE CONDITIONS

The site is a water treatment plant with extensive underground piping and various structures (e.g., basins, ponds, and vault structures). The ground surface generally slopes down to the northeast and has little vegetative cover. Immediately north of the site is the Welby Jacobs Canal and in other directions the surrounding areas are generally undeveloped except for a couple of roadways.

SUBSURFACE CONDITIONS

Biek (2005) maps four surficial geologic units at the JVWTP site. In the southeast portion of the plant where embankments constituting the water storage ponds have been constructed, soils are mapped as "artificial fill" (unit Qf). Along 3200 West (north of the main gate) and also adjacent to some of the fill, soils are described as younger (Holocene and upper Pleistocene) alluvial fan deposits consisting of poorly stratified and poorly sorted (in the geologic sense) sand, silt, and gravel (unit Qaf1). Near this unit Qaf1 (and apparently also underlying portions of it), are soils described as lacustrine gravel and sand deposited in beaches during the uppermost Pleistocene (unit Qlgp). Most of the plant proper and the area of the proposed upgrades/improvements which are the subject of this study (except where the new pipeline is to be placed in the embankment fill) are located on material mapped as lacustrine sands consisting of sand and some silt and gravel again deposited in upper Pleistocene beaches which may locally include eolian deposits (unit Qlsp).

Previous experience indicates that cobble- and boulder-sized materials are found in the area of the plant.

Based on our field study, subsurface conditions at the site may be generally described as follows:

- Embankment Fill – Medium dense to very dense silty to clayey sand (SM to SC) and stiff to very stiff sandy lean clay (CL). Native contact was found between 0 and 22 feet below existing site grades.
- Native Ground – medium dense to very dense, silty to clayey sand (SM to SC) with gravel, possible cobbles, and boulders. Occasional sandy silt layers.

Groundwater

Groundwater was not found to any significant degree in any of the test holes completed for this study. A brief review of published water well logs in the general vicinity of the project site suggests a static water level on the order of 100 to 175 feet below the ground surface. Note that an apparently isolated perched groundwater zone was found in test hole 19-TH-04 at about 12.5 feet below site grade.

A standpipe piezometer was installed in test hole 19-TH-05 for evaluation of groundwater conditions. We revisited the project site on February 4, 2020 (approximately 4 weeks following completion of drilling) to measure the water level in the piezometer. The piezometer was found to be dry. Note that the unlined ponds in the northeast corner of the site, nearest the test holes, were empty both during drilling and at the time of piezometer measurement.

We expect groundwater levels to remain well below construction excavations contemplated on this project, provided that ponds remain dry. The wet zone observed in 19-TH-04 suggests the possibility of perched water zones, however, based on the soil conditions observed we expect these zones to be isolated. We recommend reevaluation of groundwater levels prior to excavation activities to confirm conditions are consistent with these observations, especially if ponds are filled or have been filled.

SEISMICITY AND SEISMIC EFFECTS

This site, situated in southern end of the Salt Lake Valley, presents a relatively high ground shaking hazard. The site is located approximately 7 miles west southwest of the nearest mapped segment of the Wasatch Fault (WFZ), being the Salt Lake City Segment. This fault segment is the largest contributor to the ground shaking hazard at the site for typical design hazard levels.

The weighted average shear wave velocity of the top 100 feet of the soil profile at the site (referred to as Vs100, a value which is often taken to be synonymous with Vs30, where the subscript of 30 denotes 30 meters rather than 100 feet) as measured in the geophysical survey is 1,826 ft/s. As such, the site classifies as Seismic Class C ("stiff soil"), per NEHRP Recommended Seismic Provisions for New Buildings and Other Structures (BSSC, 2015) which is the document underlying the 2018 International Building Code (IBC) and design standard ASCE 7-16.

Table 3 presents seismic design parameters consistent with the general spectral acceleration response spectrum procedure (with 5% damping) of the 2018 IBC (USGS, 2020a; ATC, 2020). Acceleration parameters presented in the table have not been adjusted to account for any particular occupancy category or seismic importance factor. Ordinarily, with respect to implementation of the seismic design provisions of the 2018 IBC, we assume that the Designer will implement code exceptions as required, rather than perform site-specific seismic studies. Based on our understanding of the structure to be designed, it appears that no such exceptions will be needed, and the seismic design parameters can be used directly without further adjustment to site coefficients or the shape of the response spectrum. However, if desired, we can provide additional information and services related to site-specific seismic studies upon request.

For deterministic-based analyses which require definition of a single "most representative" earthquake, modal values from a deaggregation of the probabilistic ground motion are often used. A deaggregation of the probabilistic portion of the MCE (maximum considered earthquake) hazard level at a structural period of zero (i.e., at peak ground acceleration, PGA) indicates that the modal magnitude-distance pair is 7.09 and 8.8 km and contributes about 31% to the total hazard, whereas the mean magnitude-distance pair is 7.02 and 9.1 km (USGS, 2020b).

Assessments of other seismic hazards such as ground rupture and liquefaction were not part of our scope.

ANALYSES AND RECOMMENDATIONS – EARTHWORK

General

We understand that construction of the upgrade features addressed in this document will not necessitate any appreciable change in grade.

Excavations

The Contractor should rely upon his own methods to determine and maintain safe and stable excavations during construction subject to his particular construction procedures and to those subsurface conditions more fully exposed during construction. All excavations should comply at a minimum with the Occupational Safety and Health Administration's

(OSHA) construction standards. All excavations should be observed by qualified personnel. The Contractor is ultimately responsible for excavation, trench and site safety.

Subgrade Preparation

Prior to backfilling any excavation and placement of general or structural fill, the subgrade should be scarified to a depth of 8 inches, moisture conditioned to within 2 percent of optimum moisture content, and compacted to a minimum of 95 percent of the maximum dry density (MDD) as determined by ASTM D 1557 (Modified Proctor). Site grading activities and compaction of subgrade materials should be observed by the Geotechnical Engineer to assess compliance with these recommendations.

Fill and Compaction

Structural Fill – All fill placed for the support of the foundations, slabs, pavements, and concrete liners should consist of structural fill. Structural fill should be limited to approved onsite granular fill soils or approved imported granular structural fill. All granular structural fill should be well graded (i.e., have a broad range of particle sizes) as well as have a maximum particle size of 3-inches, a fines content (material passing the #200 mesh sieve) between 5 and 25 percent, and a plasticity index of 6 or less. Fill materials should be free from deleterious materials such as snow, ice, frozen materials, organics, and debris. Materials used as structural fill should not be chemically aggressive toward concrete or ferrous materials. Some excavated onsite soils may meet these requirements with processing and removal of oversized materials.

Structural fill materials should be moisture conditioned to within 2 percent of optimum moisture content and compacted on a horizontal plane in maximum 8-inch loose lifts to a minimum of 95 percent of maximum dry density (MDD) in accordance with ASTM D 1557 (modified Proctor compaction effort).

Given our understanding of the project, general fill will not be needed for the project, and hence recommendations regarding general fill have not been provided.

Pipe bedding, pipe zone backfill, and trench zone backfill recommendations are outside our scope of work.

ANALYSES AND RECOMMENDATIONS – BURIED VAULT

General

We understand that the proposed vault (20- by 12- by 10-foot deep) will be constructed of reinforced concrete and buried entirely below grade. Given the absence of an observable water table within the proposed depth of the vault, we do not anticipate that flotation will be an issue.

Bearing Capacity and Settlement

Foundations for the vault should bear directly on undisturbed, dense to very dense in-place native granular soils or properly prepared structural fill. To minimize the potential for differential settlement we recommend all footings and the reinforced concrete slab bear on at least 4 inches of compacted structural fill or dense in-place native granular soils; no footing should bear directly on boulders or bedrock.

Disturbed or loose native soils should be removed and replaced as directed by the Geotechnical Engineer. An allowable bearing capacity (i.e., resistance) of 5,000 psf can be used for the design of both strip and spot footings under static loading conditions. This value is based on a nominal minimum factor of safety of 3 against general shear failure, footing widths (square and strip) of at least 2 feet, and estimated settlements as described below. This bearing capacity is a net allowable value, meaning that the weight of all components above the foundation bearing level up to (but below) the lowest adjacent grade need not be included in the calculation of the structural bearing load when making comparison(s) with allowable bearing capacity.

The allowable bearing capacity for static load conditions may be increased by one-third for temporary loading conditions such as transient wind and seismic loadings.

Given that the structure in question is a buried vault, and that the weight of soil removed from within its structural envelope is expected to be greater than the weight of the structure itself, the amount of post-construction settlement resulting from static loads is expected to be negligible.

Modulus of Subgrade Reaction

We understand that the floor slab of the vault will not be designed as a structural slab. As such, a modulus of subgrade reaction has not been developed.

Lateral Earth Pressures

Lateral earth loads acting on the vault under static and seismic conditions may be computed using the earth pressure coefficients listed in Table 4. Elements that can move or deflect sufficiently to develop the strength of the soils and backfill behind a wall can be designed assuming “active” lateral earth pressures for structures. A movement or rotation equal to about 0.2 percent of the buried depth of the element is usually considered to be required to develop lateral earth pressures adjacent to granular soils. “At-rest” lateral earth pressures are generally assumed for buried structural elements that are designed for little or no movement/rotation. Passive lateral earth pressures are generally assumed to resist structure movement. Structure movement of at least 2 percent of the buried depth of the structure element is generally associated with full passive lateral earth pressures. Walls that support potentially “movement sensitive” facilities should be designed using at-rest earth pressures. Buried tanks, vaults, or walls whose movement is restrained along their bottom and top should also likely be designed using at-rest earth pressures.

For seismic analyses, the earth pressure coefficients in the table only account for the dynamic horizontal thrust produced by ground motion. Hence, the resulting dynamic thrust pressure should be added to the static pressure to determine the combined pressure acting on the wall. In the case of at-rest seismic earth pressure conditions, pressures calculated using the traditional approach of Wood (1973) or the more recent approach of Ostadan (2005) can be quite large and relatively problematic for design. There is a growing body of work by researchers such as Sitar that suggest both active and at-rest seismic earth pressures may, in many cases, be lower than those predicted by more classical (traditional) theories. It should be recognized that at this point, such research results have been acknowledged by, but not generally incorporated into, seismic design documents such as NEHRP Recommended Seismic Provisions for New Buildings and Other Structures, which underlies IBC 2018 and ASCE 7-16 (BSSC, 2015). Consistent with this state of practice, a range of seismic earth pressure coefficients are shown in the table, with the higher, at-rest pressures corresponding to those obtained using more traditional, code-based analysis methods. It should also be noted that other recent research findings place the dynamic resultant force for active and at-rest conditions above the toe of the wall a distance between 0.3 and 0.5 times the wall height. For walls with sloping ground either in front or behind them, global stability should explicitly be checked as part of the final design. Walls with surcharge loads should similarly be checked.

Unless indicated otherwise, the lateral earth pressure coefficients provided in the table assume horizontal backfill and vertical wall face conditions. Unless indicated otherwise, hydrostatic pressures and surcharge loadings should be added to lateral earth pressures as applicable. Over-compaction behind walls should be avoided. Resistive passive earth pressures developed from soils subject to frost or heave, or otherwise above prescribed minimum depths of foundation embedment, should usually be neglected in design.

Lateral Sliding Resistance

Although the structure is a buried vault and lateral movement will be restrained by backfill acting against opposing side walls, if one wishes to assess sliding along the base of the structure, a coefficient of friction of 0.5 may be used when the structure bears on structural fill or properly prepared subgrade. Being an ultimate value, this factor should be considered as representing the maximum resistance to sliding before displacement occurs (i.e., it contains no inherent factor of safety against sliding).

ANALYSES AND RECOMMENDATIONS – RECLAIM POND LINER

We understand that the existing reclaim (formerly backwash) ponds are approximately 12 feet deep, and lined with a membrane and overlying gravel cushion. We understand that the ponds will be relined using a concrete liner to help facilitate removal of accumulated solids. We understand that excavation and handling of the solids is planned to be done using a large, rubber-tired backhoe (such as a Case 580) or similarly sized front-end loader, together with a 10-wheel type dump truck or similar. Removal of accumulated solids is expected to be on an infrequent basis (up to perhaps a couple of times per year).

We understand that there are no known seepage or observable surface seepage issues between the adjacent reclaim ponds, and hence uplift pressure on the liner is not a design consideration.

With a properly prepared subgrade, we recommend that a subgrade modulus of 220 pci (reflective a 1-foot diameter vertical loading) be used for design of the liner. Based on the anticipated vehicle/equipment loads, absent any design to the contrary, we recommend that a minimum 6-inch thick concrete slab be used as the liner. The Portland cement concrete should have a 28-day compressive strength of at least 4,000 psi, an associated modulus of rupture of at least 650 psi, and other properties (including air entrainment) consistent with American Concrete Institute (ACI) guidelines. We also recommend that the slab be reinforced using #4 bars at 12-inch centers, each way. Such reinforcement not only provides temperature and shrinkage cracking control, but also provides some load transfer across joints. We recommend that a panel size (joint spacing) of 14 by 14 feet be used. We recommend that the concrete be placed on at least 4 inches of compacted granular base. These recommendations primarily reflect structural considerations and do not address potential hydraulic considerations associated with how the ponds are intended to function. As such, these recommendations may need to be modified to reflect design levels of infiltration and/or underlying seepage collection.

ANALYSES AND RECOMMENDATIONS – LOCAL STABILITY FOR PIPELINE INSTALLATION ALONG STORAGE POND SLOPES

Stability analyses were performed to evaluate the relative destabilizing effect of the pipe excavation on the pond embankment slopes. *Note that this evaluation does not purport to constitute a stability evaluation of the existing embankment configuration, merely an assessment of the relative impact of the proposed excavation*. We understand the new pipe will be buried 3 to 8 feet below existing grade. We are not aware of any significant regrading of the existing slopes planned as part of this project.

Our stability analyses considered two cross-sections: Station 2+00 and Station 13+00 as shown on Carollo civil drawings, Sheets No. C-05 and C-08, developed for the project and dated August 2019. These sections were selected as they were observed to be steeper, relative to other sections. The Station 13+00 cross-section shows the proposed pipe excavation near the base of the slope, with the excavation extending into likely native soil materials. The side slope of the embankment as shown is 2.4:1 (H:V). The pipe is nearer the top of the embankment in the Station 2+00 section and the trench excavation will be confined to embankment fill. The side slope of this cross-section is approximately 2.7:1. The excavation for the pipeline was modeled with a 1.5:1 (H:V) cut-back slope and base width of 5 feet in both cross-sections.

Stability of the referenced sections were evaluated using the computer program SLOPE/W by Geo Studio, and the Morgenstern-Price stability analysis method, which considers both force and moment equilibrium for a collection of slices bound by the potential slip surface. The embankments were evaluated without the excavation first and then with the excavated soil removed. We understand that there are no known seepage or observable surface seepage issues with the large storage ponds. For the purposes of these analyses, we assumed the embankments had not developed a phreatic (groundwater) surface which would affect to local pipe trench excavation. A phreatic surface tends to destabilize an embankment relative to the dry conditions modeled. We assume and recommend excavation for the pipeline be performed when the adjacent ponds are empty and embankments are not saturated.

Material properties used in the stability model were developed using field and laboratory data, established correlations, as well as our experience and judgment. A summary of the soil parameters is provided in Table 5. The results of stability analyses are presented in Figures 3 through 6. Our evaluation reveals the excavation will reduce the factor of safety from approximately 2.0 to 1.3. A factor of safety of 1.3 is typically considered acceptable for temporary construction cases with these types of slopes. We note that the excavations equate to about a 70% reduction in the relative margin of safety for the slopes, meaning that while the factor of safety of margin is considered acceptable, particular care should be exercised during construction as noted below. The critical slip surfaces for the two excavations are relatively shallow, representing a raveling type of distress mechanism rather than a deeper seated (and more problematic) failure. As such, we believe it to be important to maintain excavation slopes at no steeper than 1.5:1 and that ponds be kept empty and embankments not be allowed to become saturated before or during construction to reduce risk of instability due to open excavations. If these considerations are not possible, trench shoring should be used and lengths of excavation limited to no more than what can be stabilized with available shoring systems.

LIMITATIONS

The assessments and recommendations presented in this document are based on limited field studies and laboratory testing, as well as our understanding of the project's design and manner of construction. If the project's design or manner of construction changes, or if conditions are found that are different from those described, we should be notified immediately so that we can make revisions as necessary. We recommend that project plans, specifications, and construction-related submittals be reviewed by Gerhart Cole for compatibility with our recommendations.

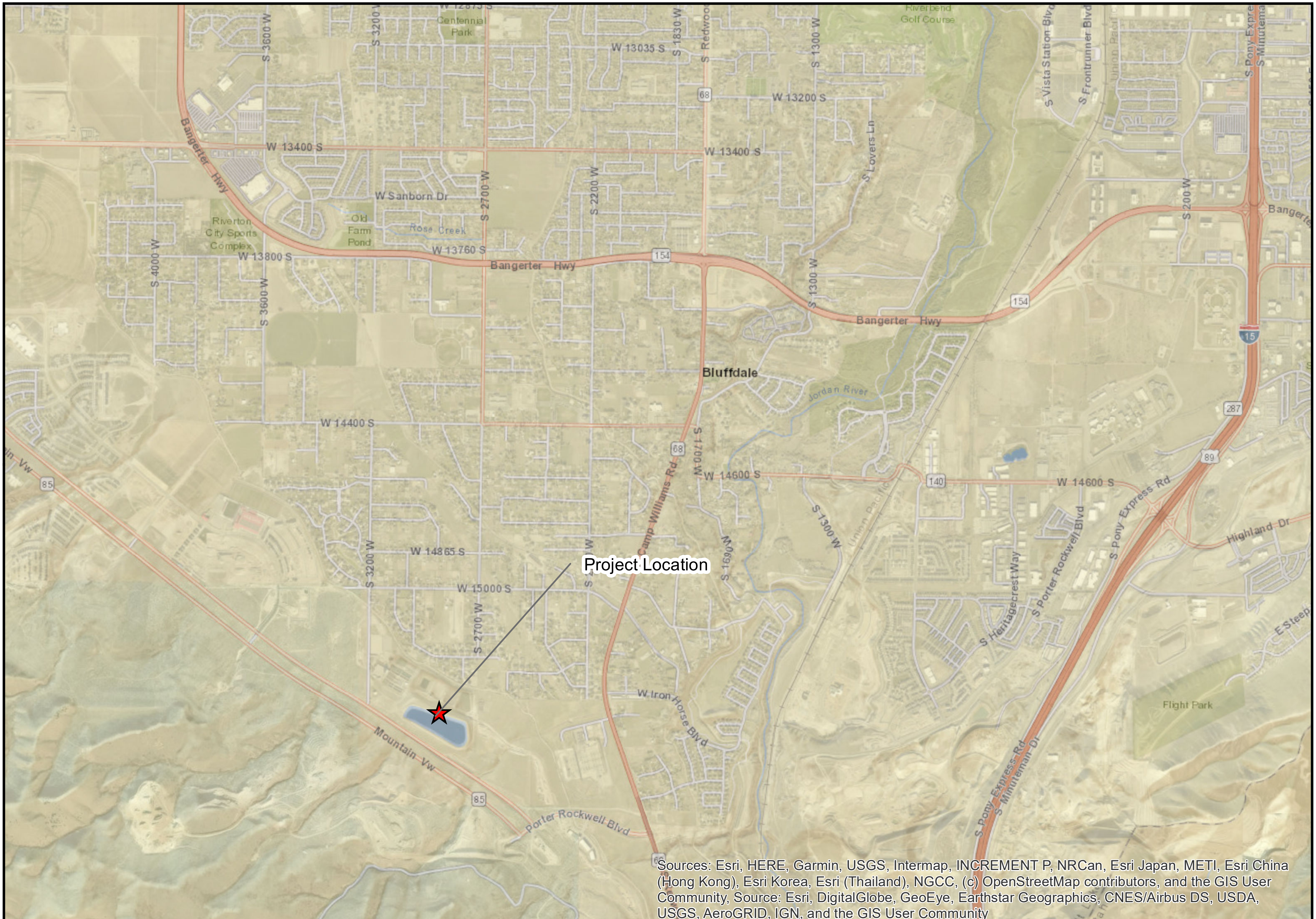
This document was prepared solely for the use of the addressee (our Client) for the specified project and may not contain sufficient information for other parties or uses. Also, this document does not constitute a specification and should not be treated or referred to as such in project design drawings or documents.

We represent that our services are performed within the limitations prescribed by our Client, in a manner consistent with the level of care and skill ordinarily exercised by other professional consultants under similar circumstances. No other representation, expressed or implied, and no warranty or guarantee is included or intended. We do not assume responsibility for the accuracy of information provided by others.

FIGURES

TABLES

APPENDICES



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Vicinity Map

Jordan Valley Water Treatment Plant Upgrades

N

0 750 1,500 3,000 Feet

Figure 1

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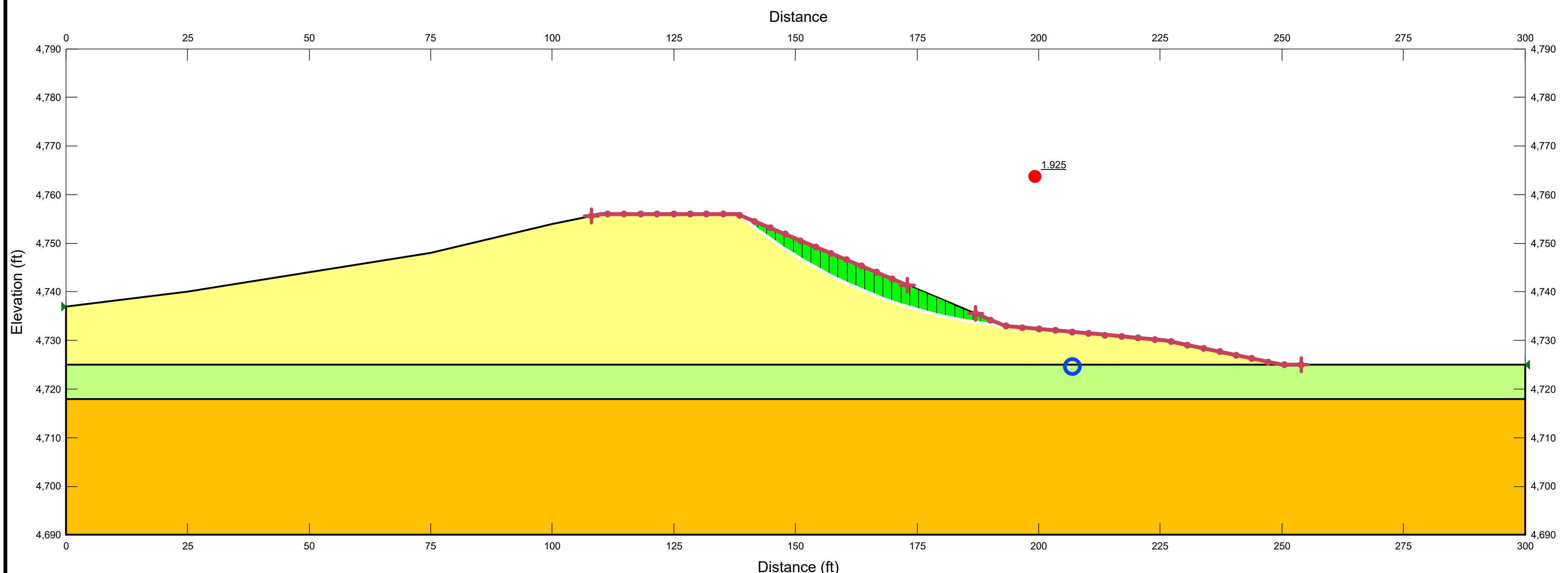
Field Studies Location Map

Jordan Valley Water Treatment Plant Upgrades

Figure 2

Color	Name
	Clayey Sand
	Dense Silty Sand
	Embankment Fill

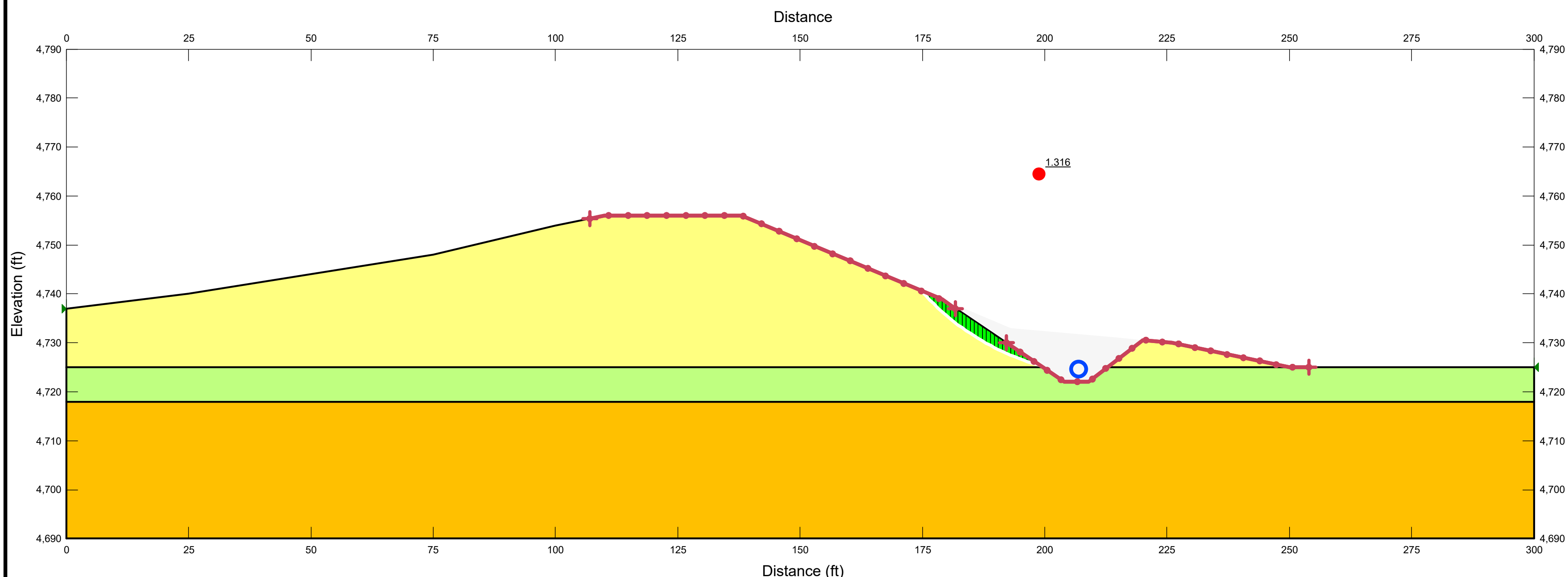
JVWCD Jordan Valley Water Treatment Plant
Local Embankment Stability
Name: Existing Conditions
Cross-section at Sta. 13+00



GERHART COLE	Stability Analysis: Existing Conditions	19-1225
	Jordan Valley Water Treatment Plant Upgrades	Figure 3

JVWCD Jordan Valley Water Treatment Plant
Local Embankment Stability
Name: Excavation
Cross-section at Sta. 13+00

Color	Name
(green)	Clayey Sand
(orange)	Dense Silty Sand
(yellow)	Embankment Fill



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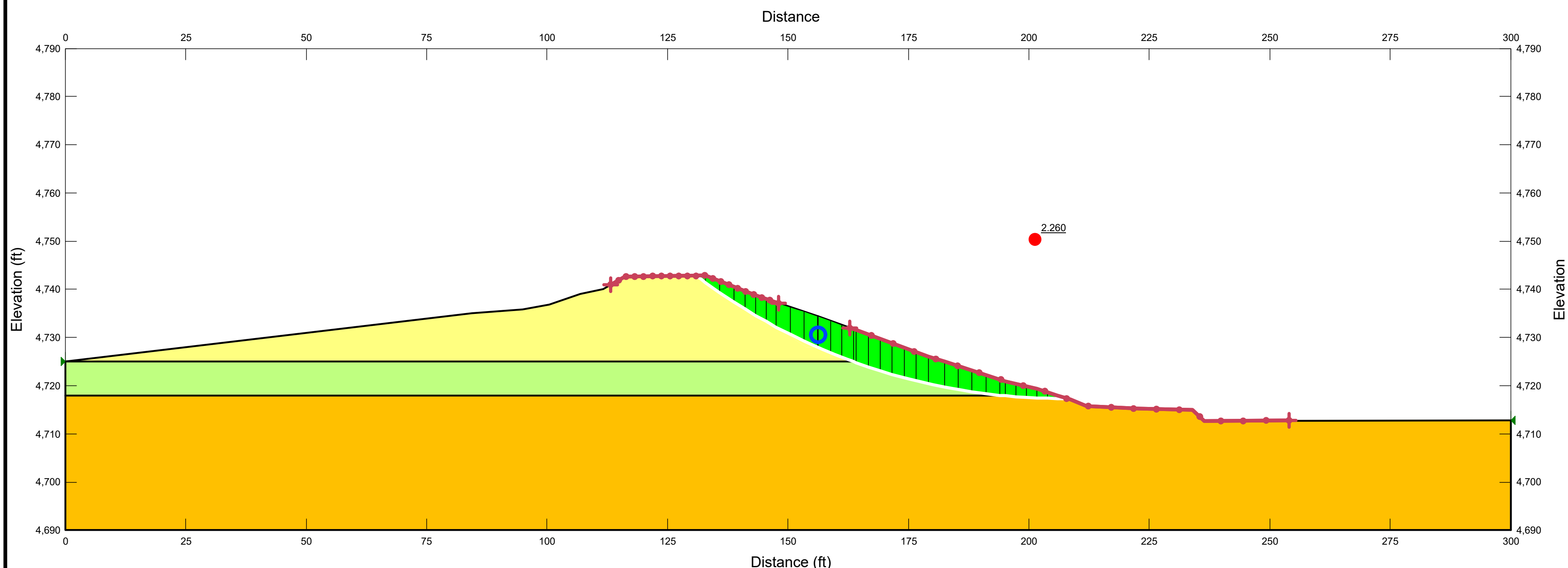
Stability Analysis: Excavation	19-1225
Jordan Valley Water Treatment Plant Upgrades	Figure 4

Color	Name
(light green)	Clayey Sand
(orange)	Dense Silty Sand
(yellow)	Embankment Fill

JVWCD Jordan Valley Water Treatment Plant
Local Embankment Stability
Name: Existing Conditions
Cross-section at Sta. 2+00



GERHART COLE	Stability Analysis: Existing Conditions	19-1225
	Jordan Valley Water Treatment Plant Upgrades	Figure 5

JVWCD Jordan Valley Water Treatment Plant
Local Embankment Stability
Name: Excavation
Cross-section at Sta. 2+00

Color	Name
(green)	Clayey Sand
(orange)	Dense Silty Sand
(yellow)	Embankment Fill

GERHART COLE	Stability Analysis: Excavation	19-1225
	Jordan Valley Water Treatment Plant Upgrades	Figure 6

Table 1 Field Studies Test Hole Data

Jordan Valley Water Treatment Plant Upgrades

Test Hole ID	Date Started	Source	Latitude[a]	Longitude[a]	Test Hole Elev. (ft)[b]	Total depth (ft)	Drilling Method	Groundwater Depth (ft)
19-TH-01	1/8/2020	Gerhart Cole	40.473960	-111.965230	4726.1	17.0	ODEX	Not found
19-TH-02	1/8/2020	Gerhart Cole	40.473720	-111.964070	4726.3	22.0	ODEX	Not found
19-TH-03	1/8/2020	Gerhart Cole	40.473320	-111.963300	4726.0	21.4	ODEX	Not found
19-TH-04	1/8/2020	Gerhart Cole	40.47302	-111.96153	4735.2	17.0	ODEX	Perched groundwater zone at 12.5 feet.
19-TH-05	1/9/2020	Gerhart Cole	40.47204	-111.95947	4743.9	30.0	ODEX	Not found

Notes:
1. Coordinates for test holes completed by Gerhart Cole were were collected with a non-survey grade GPS.
2. Test hole elevations were obtained from LiDAR data published by Utah Geologic Survey.

Table 2 Laboratory Test Results Summary

Jordan Valley Water Treatment Plant Upgrades

Test Hole	Depth (ft)	Moisture content (%)	Atterberg Limits					Grain-Size			Grain-Size Analysis (Percent Finer)										Other Tests
			LL (%)	PL (%)	PI (%)	Cohesive Index, CI	Liquidity Index, LI	GRAVEL (No.4 - 3")	SAND (No.200-No.4)	FINES (<No.200)	1.5-in (37.5 mm)	3/4-in (19 mm)	3/8-in (9.5 mm)	No.4 (4.75 mm)	No.10 (2 mm)	No.20 (0.85 mm)	No.40 (0.425 mm)	No.60 (0.25 mm)	No.100 (0.15 mm)	No.200 (0.075 mm)	
19-TH-01	5-7	10.0																			
19-TH-01	10-11.9	16.5						26	58	16	100	91	84	74	62	50	43	31	24	16	
19-TH-01	15-17	13.2																			
19-TH-02	5-7	13.8	25	14	11	0.8	0.0														
19-TH-02 & 19-TH-03	10-20	11.1	NP	NP	NP			20	59	21	100	99	94	80	65	53	43	36	29	21	Compaction, CBR
19-TH-02	15-17	10.4																			
19-TH-02	20-22	11.9						23	59	18	100	93	87	77	64	51	40	32	24	18	
19-TH-03	0-2	12.1																			
19-TH-03	10-12	13.6																			
19-TH-03	12.5-13.4	9.7						36	51	12	100	89	78	64	50	40	31	24	18	12	
19-TH-03	15-17	7.9																			
19-TH-03	20-21.4	11.1						17	63	20	100	96	92	83	69	54	43	34	27	20	
19-TH-04	0-2	14.6																			
19-TH-04	2.5-4.5	11.5						23	54	24	100	91	85	77	66	56	48	40	32	24	
19-TH-04	5-7	14.1																			
19-TH-04	10-12	11.8						28	52	20	100	89	81	72	60	59	39	32	26	20	
19-TH-04	12.5-14.5	17.2																			
19-TH-04	15-17	12.7																			

Table 2 Laboratory Test Results Summary

Jordan Valley Water Treatment Plant Upgrades

GERHART COLE

Test Hole	Depth (ft)	Moisture content (%)	Atterberg Limits					Grain-Size			Grain-Size Analysis (Percent Finer)										Other Tests
			LL (%)	PL (%)	PI (%)	Cohesive Index, CI	Liquidity Index, LI	GRAVEL (No.4 - 3")	SAND (No.200-No.4)	FINES (<No.200)	1.5-in (37.5 mm)	3/4-in (19 mm)	3/8-in (9.5 mm)	No.4 (4.75 mm)	No.10 (2 mm)	No.20 (0.85 mm)	No.40 (0.425 mm)	No.60 (0.25 mm)	No.100 (0.15 mm)	No.200 (0.075 mm)	
19-TH-05	5-7	11.0																			
19-TH-05	10-20	13.3						14	57	29	100	100	97	86	78	68	58	50	41	29	
19-TH-05	12.5-14.5	10.9																			
19-TH-05	15-17	13.1						28	53	20	100	91	81	72	61	50	40	33	27	20	
19-TH-05	17.5-19.5	9.7																			
19-TH-05	20-22	14.2						22	44	34	100	86	83	78	71	61	54	49	42	34	
19-TH-05	20-30	11.6						10	56	33	100	99	95	90	81	68	57	50	42	33	
19-TH-05	25-25.9	10.5																			
19-TH-05	28-30	6.3																			

Table 3 Seismic Design Parameters
Jordan Valley Water Treatment Plant Upgrades

Site Class	Type of MCE Acceleration	Mapped [B/C Boundary] Acceleration (g)			Site Coefficient			Design Acceleration (g)			
C	Risk-targeted (structural)	- - -	S_S	S_1	- - -	F_a	F_v	Multiplier	PGA_R	S_{DS}	S_{D1}
		- - -	1.18	0.43	- - -	1.20	1.50	0.667	0.38	0.94	0.43
		(with exceptions, if any)			- - -	(1.20)	(1.50)		(0.38)	(0.94)	(0.43)
	Geo-mean (geotechnical)	PGA	- - -	- - -	F_{pga}	- - -	- - -	Multiplier	PGA_M	- - -	- - -
		0.52	- - -	- - -	1.20	- - -	- - -	1.0	0.63	- - -	- - -
		(with exceptions, if any)			(1.20)	- - -	- - -		(0.63)	- - -	- - -

Notes:
1. TL = 8 sec.
2. "N/A" indicates site specific study is required.
3. No exceptions taken.

Table 4 Lateral Earth Pressures

Jordan Valley Water Treatment Plant Upgrades

GERHART COLE

Material	Moist Unit Weight (pcf)	Earth Pressure Coefficients				
		Active Static	Active Seismic Component	At-Rest	At-Rest Seismic Component	Passive Static
Compacted Structural Fill / Backfill	130	0.28	0.13	0.44	0.29 to 0.38	3.54

Table 5 Slope Stability Parameters
Jordan Valley Water Treatment Plant Upgrades

Material	GeoStudio Name	Unit Weight (pcf)	Drained Friction Angle, ϕ', (degrees)	Cohesion, c' (psf)	Data Source
Embankment Fill	Embankment Fill	120	36	15	GC Evaluation, after NAVFAC
Upper Native Clayey Sand	Clayey Sand	115	33	50	GC Evaluation, after NAVFAC
Lower Dense Silty Sand	Dense Silty Sand	120	37	0	GC Evaluation, after NAVFAC

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Appendix A

GERHART COLE

Jordan Valley Water Treatment Plant Upgrades
Test Hole Logs and Piezometer

Project No.: 19-1225

Table of Contents

Unified Soil Classification System (USCS)

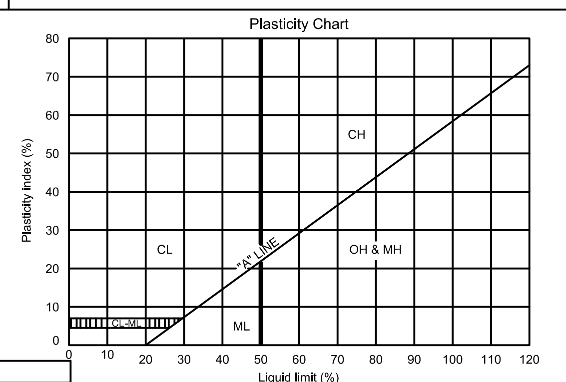
Material Types	Major Soil Divisions		Group Symbol and Legend	Typical Names
COARSE-GRAINED SOILS >50% retained on No. 200 sieve	GRAVELS >50% of coarse fraction retained on No. 4 Sieve	Clean GRAVELS (little or no fines)	GW	Well-Graded GRAVEL, GRAVEL-sand mixtures, few fines
			GP	Poorly-Graded GRAVEL, GRAVEL-sand mixtures, few fines
		GRAVELS with fines (appreciable amount of fines)	GM	Silty GRAVEL, GRAVEL-sand silt mixtures
			GC	Clayey GRAVEL, GRAVEL-sand clay mixtures
	SANDS >50% of coarse fraction passing the No. 4 sieve	Clean SANDS (little or no fines)	SW	Well-Graded SAND, SAND-gravel mixtures, few fines
			SP	Poorly-Graded SAND, SAND-gravel mixtures, few fines
		SANDS with fines (appreciable amount of fines)	SM	Silty SAND, SAND-silt mixtures
			SC	Clayey SAND, SAND-clay mixtures
FINE-GRAINED SOILS >50% Passing No. 200 Sieve	SILTS and CLAYS liquid limit < 50	Inorganic 1) CF > 30%: + Sandy/Gravelly 2) CF = 15-30% + with sand/gravel	CL	Lean CLAY, Gravelly/Sandy CLAY, low to med. plasticity
			ML	SILT, Gravelly/Sandy SILT, no to slight plasticity
		Organic	OL	Organic CLAY or SILT
	SILTS and CLAYS liquid limit > 50	Inorganic 1) CF > 30%: + Sandy/Gravelly 2) CF = 15-30% + with sand/gravel	CH	Fat CLAY, Gravelly/Sandy Fat CLAY, high plasticity
			MH	Elastic SILT, Gravelly/Sandy Elastic SILT, low to high plasticity
		Organic	OH	Organic CLAY or SILT
Highly organic soils		Primarily Organic Matter; Organic Odor	PT	PEAT
Boulders / Cobbles		> 50% (by volume) particles > 3"	COBBLES BOULDERS	Boulders (>12"); Cobbles (>3" and <12")

Other Material Symbols

- Bedrock
- Asphalt
- Concrete
- Topsoil
- Fill

Sample Types

- Auger Cuttings
- Continuous sampler
- Grab Sample
- No Recovery
- Shelby Tube
- Standard Penetration Test (SPT)
- California Sampler
- Rock Core
- Modified California Sampler
- Other (see remarks)
- Piston Sampler (Shelby Tube)
- Vane Shear



Apparent water level — Measured water level

Descriptors for Coarse Grained Soils

Apparent Density	Dr (%)	SPT	MC	CAL
Very Loose	0-15	<4	<6	<8
Loose	15-35	4-10	6-15	8-20
Med. Dense	35-65	10-30	15-42	20-56
Dense	65-85	30-50	42-72	56-96
Very Dense	85-100	>50	>72	>96

Descriptors for Fine Grained Soils

Consistency	Su (psf)	SPT	MC	CAL
Very Soft	< 250	<2	<2	<2
Soft	250-500	2-4	2-4	2-5
Med. Stiff	500-1000	4-8	4-10	5-11
Stiff	1000-2000	8-15	10-19	11-22
Very Stiff	2000-4000	15-30	19-37	22-45
Hard	>4000	>30	>37	>45

SPT - Standard split spoon (SPT): 2" OD, 1.375" ID
MC - Modified California: 2.5" OD, 1.875" ID
CAL - California: 3" OD, 2.375" ID
R - Practical Refusal For Sampling Method

Stratification

Description	Criteria
Seam	1/16" to 1/2"
Layer	1/2" to 12"
Occasional	<= 1 per ft. thickness
Frequent	> 1 per ft. thickness

Modifiers

Description	Est. (%)
Trace	<5
Some	5-12
With	12-30
-ly	>30

Descriptors for Moisture

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

Descriptors for Particle Size

Description	Criteria
Boulder	>12" : larger than a basketball
Cobble	3-12" : larger than a grapefruit
Coarse Gravel	3/4-3" : larger than a grape
Fine Gravel	No.4-3/4" : larger than a pea
Coarse Sand	No.10-4 : larger than a rock salt grain
Medium Sand	No.40-10 : larger than window screen opening
Fine Sand	No.200-40 : larger than a sugar grain

Descriptors for Particle Angularity

Description	Criteria
Angular	Sharp edges, rel. plane sides, unpolished surface
Subangular	Similar to angular, but with rounded edges
Subrounded	Nearly plane sides, well-rounded corners & edges
Rounded	Smoothly curved sides and no edges

Abbreviations for Laboratory Testing

Description	Criteria
Su	Peak Shear Stress
CORR	Corrosion - Resistivity
UU	Unconsolidated Undrained Triaxial
CON	One-dimensional Consolidation
AL	Atterberg Limits (LL=Liquid Limit & PI=Plasticity Index)
SV	Sieve / Grain-Size Distribution Testing

Abbreviated Soil Classification Symbols (after ASTM D2488 X.5)

Prefix	Suffix
s = sandy	s = with sand
g = gravelly	g = with gravel
	c = with cobbles
	b = with boulders

Abbreviated system for supplementary presentations when complete description is referenced. Examples:

Group Symbol and Full Name	Abbreviated
Sandy Lean CLAY	s(CL)
Poorly Graded SAND with silt and gravel	(SP-SM)g
Poorly Graded Gravel with sand, cobbles, and boulders	(GP)scb
Gravelly SILT with sand and cobbles	g(ML)sc

General Notes:
1) Stratigraphic lines on the logs represent approximate boundaries.
2) No warranty is provided as to the continuity of soil conditions beyond or between points explored and sample locations.
3) Logs represent soil conditions observed at the point of exploration on the date indicated.
4) Visual methods were used to classify the materials in general accordance with Unified Soil Classification System; actual designations based on laboratory methods may vary.

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Legend to Soil Descriptions

A-01

Project: Jordan Valley Water Treatment Plant Upgrades
Project Location: Salt Lake County, UT
Project Number: 19-1225

LOG OF TEST HOLE 19-TH-01

Date(s) Drilled	01/08/2020 to 01/08/2020	Logged By	J. McFarlane	Checked By	D. Billings
Drilling Method	ODEX	Drill Bit Size/Type	4.5 inch ODEX Ring Bit	Total Depth Drilled (feet)	17.0
Drill Rig Type	Fraste Multidrill XL	Drilling Contractor	ConeTec (Ryan, Kenny)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	Not Found	Latitude / Longitude	40.47396 , -111.96523	Ground Surface Elevation (feet)	4726.1 (Approx.)
Comments		Test Hole Backfill	Bentonite Chips and Cuttings	Elevation Datum	

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
	0–2	SPT	SPT-1	5-6-8-19 14	21		CLAY, some sand, trace gravel - stiff, moist, tan to light brown, low plasticity, (CL)	
	2.5–4	SPT	SPT-2	17-20-45-50 65	22		SAND, silty, some gravel - very dense, moist, tan to light brown, fine to coarse sand, fine to medium gravel, (SM) -transitions to gray	
4722	5–6.5	SPT	SPT-3	17-10-10-19 20	20		SAND, clayey, with gravel - medium dense, moist, brown to reddish brown, fine to coarse sand, (SC)	
4717	7.5	SPT	SPT-4	37-50/3" [R]	7		SAND, silty, with gravel - very dense to medium dense, brown to reddish brown, fine to coarse sand, (SM)	
	10	SPT	SPT-5	19-18-24-50/5" 42	18			
4712	15	SPT	SPT-6	10-13-12-22 25	20			
4707	17–20						Bottom of Hole at 17 feet	

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Project: Jordan Valley Water Treatment Plant Upgrades

Project Location: Salt Lake County, UT

Project Number: 19-1225

LOG OF TEST HOLE 19-TH-02

Date(s) Drilled	01/08/2020 to 01/08/2020	Logged By	J. McFarlane	Checked By	D. Billings
Drilling Method	ODEX	Drill Bit Size/Type	4.5 inch ODEX Ring Bit	Total Depth Drilled (feet)	22.0
Drill Rig Type	Fraste Multidrill XL	Drilling Contractor	ConeTec (Ryan, Kenny)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	Not Found	Latitude / Longitude	40.47372 , -111.96407	Ground Surface Elevation (feet)	4726.3 (Approx.)
Comments		Test Hole Backfill	Grout	Elevation Datum	

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
	0–2	X	SPT-1	5-5-7-8 12	19		CLAY, sandy, trace gravel - stiff, moist, light brown to brown, low to medium plasticity, (CL), [FILL]	
4722	4						CLAY, some sand -very stiff, moist, brown to dark brown, medium plasticity, (CL), [FILL]	
	5–7	X	SPT-2	3-6-14-25 20	23			
4717	8.5						SAND, silty, with gravel - medium dense to very dense, moist, light brown to brown, fine to coarse sand, fine and medium gravel, (SM)	Attempted to push shelby tube, practical refusal at 2 inches. Bulk sample of cuttings from 10 to 20 feet.
	10–12	X	SPT-3	21-18-20-34 38	22			
	12.5–14.5	X	SPT-4	49-40-31-28 71	24			
	13.5						SILT, sandy - hard, moist, brown to reddish brown, fine to medium sand, (ML)	
4712	14.8						SAND, silty, with gravel - very dense, moist, light brown to brown, fine to coarse sand, fine and coarse gravel, (SM)	
	15–17	X	SPT-5	26-40-33-50/5" 73	23			
	17.5–19.5	X	SPT-6	15-19-22-28 41	24			
4707	20–22	X	SPT-7	17-25-38-43 63	24			
4702	22						Bottom of Hole at 22 feet	
	25							

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Project: Jordan Valley Water Treatment Plant Upgrades	**LOG OF TEST HOLE 19-TH-03**
Project Location: Salt Lake County, UT	
Project Number: 19-1225	**Sheet 1 of 1**

Date(s) Drilled	01/08/2020 to 01/08/2020	Logged By	J. McFarlane	Checked By	D. Billings
Drilling Method	ODEX	Drill Bit Size/Type	4.5 inch ODEX Ring Bit	Total Depth Drilled (feet)	21.5
Drill Rig Type	Fraste Multidrill XL	Drilling Contractor	ConeTec (Ryan, Kenny)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	Not Found	Latitude / Longitude	40.47332 , -111.96330	Ground Surface Elevation (feet)	4726.0 (Approx.)
Comments		Test Hole Backfill	Grout	Elevation Datum	

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
	0	X	SPT-1	7-18-17-14 35	13		SAND, clayey, some gravel - dense, moist, light brown to brown, fine to coarse sand, (SC)	
	3.5						CLAY, sandy, with gravel - very stiff, brown to dark brown, (CL)	
4721	5	X	SPT-2	12-13-13-15 26	21			
	7.5						SAND, silty, some gravel - dense, moist, tan to light brown, fine to coarse sand, carbonate staining, (SM)	
4716	10	X	SPT-3	12-21-28-50/4" 49	22			Bulk sample of cuttings from 10 to 20 feet.
	12.5	X	SPT-4	26-50/5" [R]	11		-very dense, increasing gravel	
4711	15	X	SPT-5	50/5.5" [R]	5			
	17.5		SPT-6	50/1" [R]	0		-possible cobbles	
4706	20	X	SPT-7	49-45-50/5" [R]	17			
	21.5						Bottom of Hole at 21.5 feet	
4701	25							

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Project: Jordan Valley Water Treatment Plant Upgrades	# LOG OF TEST HOLE 19-TH-04
Project Location: Salt Lake County, UT	
Project Number: 19-1225	**Sheet 1 of 1**

Date(s) Drilled	01/08/2020 to 01/08/2020	Logged By	J. McFarlane	Checked By	D. Billings
Drilling Method	ODEX	Drill Bit Size/Type	4.5 inch ODEX Ring Bit	Total Depth Drilled (feet)	17.0
Drill Rig Type	Fraste Multidrill XL	Drilling Contractor	ConeTec (Ryan, Kenny)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	12.52	Latitude / Longitude	40.47302 , -111.96153	Ground Surface Elevation (feet)	4735.2 (Approx.)
Comments		Test Hole Backfill	Grout	Elevation Datum	

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
		X	SPT-1	2-3-7-11 10	17		CLAY, sandy, trace gravel - stiff, moist, dark brown to black, (CL), [TOPSOIL]	
							SAND, clayey, with gravel - medium dense, moist, light brown to brown, carbonate staining, (SC), [FILL]	
		X	SPT-2	16-11-4-3 15	16			
4731	5							
		X	SPT-3	4-14-20-17 34	15		-sandy gravel layer	
							SAND, silty, with gravel - dense, moist, light brown to brown, fine to coarse sand, fine and coarse gravel, (SM), [FILL]	
		X	SPT-4	15-19-15-12 34	18			
4726	10							
		X	SPT-5	13-12-12-19 24	7			
							▽ (groundwater)	
		X	SPT-6	8-7-14-25 21	19		CLAY, sandy, some gravel - stiff, moist, dark brown to black, (CL)	
4721	15						SAND, clayey, with gravel - medium dense, moist, brown to dark brown, (SC)	
		X	SPT-7	12-10-10-14 20	21			
							Bottom of Hole at 17 feet	
4716	20							

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Project: Jordan Valley Water Treatment Plant Upgrades	**LOG OF TEST HOLE 19-TH-05**
Project Location: Salt Lake County, UT	
Project Number: 19-1225	**Sheet 1 of 1**

Date(s) Drilled	01/09/2020 to 01/09/2020	Logged By	J. McFarlane	Checked By	D. Billings
Drilling Method	ODEX	Drill Bit Size/Type	4.5 inch ODEX Ring Bit	Total Depth Drilled (feet)	30.0
Drill Rig Type	Fraste Multidrill XL	Drilling Contractor	ConeTec (Ryan, Kenny)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	Not Found	Latitude / Longitude	40.47204 , -111.95947	Ground Surface Elevation (feet)	4743.9 (Approx.)
Comments	See piezometer completion log for details.	Test Hole Backfill	Standpipe Piezometer	Elevation Datum	

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
	0	X	SPT-1	6-8-20-35 28	12		SAND, silty, with gravel, with clay- medium dense to very dense, moist, light brown to brown, fine to medium sand, fine to coarse gravel, (SC-SM), [FILL]	
4739	5	X	SPT-2	18-28-39-50/5" 67	18			
4734	10	X	SPT-3	15-15-17-25 32	24			Bulk sample of cuttings from 10 to 20 feet.
		X	SPT-4	11-27-29-25 56	19			
4729	15	X	SPT-5	12-18-12-17 30	22			
		X	SPT-6	25-27-18-13 45	4		-possible cobbles	
							SAND, clayey, with gravel, - medium dense, moist, dark brown to black, fine to coarse sand, occasional cobbles, (SC)	
4724	20	X	SPT-7	3-5-8-5 13	14			Bulk sample of cuttings from 20 to 30 feet.
							SAND, silty, with gravel, some clay - very dense, moist, light brown to brown, fine to coarse sand, fine and coarse gravel, occasional cobbles, (SC-SM)	
4719	25	X	SPT-8	10-50/5" [R]	8			
							SAND, gravelly, with silt - very dense, moist, light brown to brown, fine to coarse sand, fine and coarse gravel, occasional cobbles, (SP-SM)	
		X	SPT-9	33-45-31-37 76	21			
4714	30							

Bottom of Hole at 30 feet

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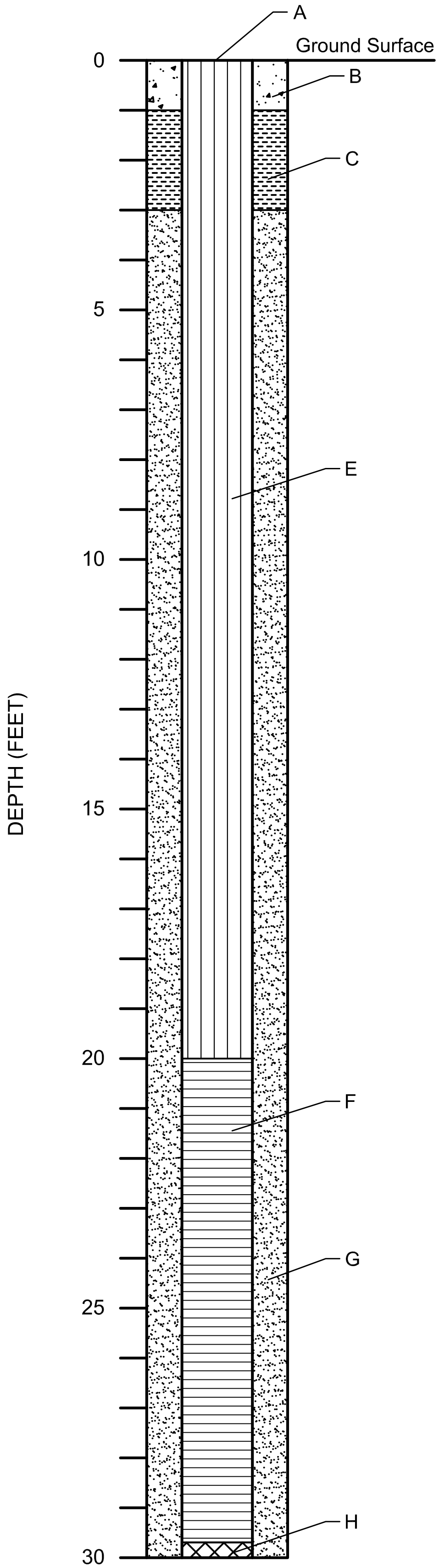


LEGEND

Water level (casing rim) at Not Found feet on 02/06/2020

- A Steel surface monument
- B Concrete surface seal
- C Bentonite Chips/Seal
- D Cement-Bentonite Grout
- E 2 -inch Schedule 40 PVC well casing
- F 2 -inch Schedule 40 PVC screen, 0.020 -inch slot width
- G 10-20 COLORADO SILICA sand backfill
- H PVC END CAP
- I
- J
- K
- L

Monument/Casing Reference Elevation: 4743.9 feet
Ground Surface Elevation: 4743.9 feet
Casing Stickup: 0.0 feet
Test Hole Drilled Diameter: 4.5 inches
Base of Test Hole: 30 feet
Base of Piezometer: 30 feet

FIELD INSTALLATION NOTES

LOCATION

Inside 19-TH-05

MATERIALS USED:

10 feet Pre-Pack Screen
20 feet Riser
5 Bags 10-20 Silica Sand
1/3 Bag Bentonite Chips
5 Bags Concrete
2 Bags Portland Cement
1 8 inch Well Cover

PIEZOMETER CONSTRUCTION DETAILS

Client: Carollo Engineers	Location: Salt Lake County	Job No.: 19-1225
By: J. McFarlane	19-TH-05	A-07

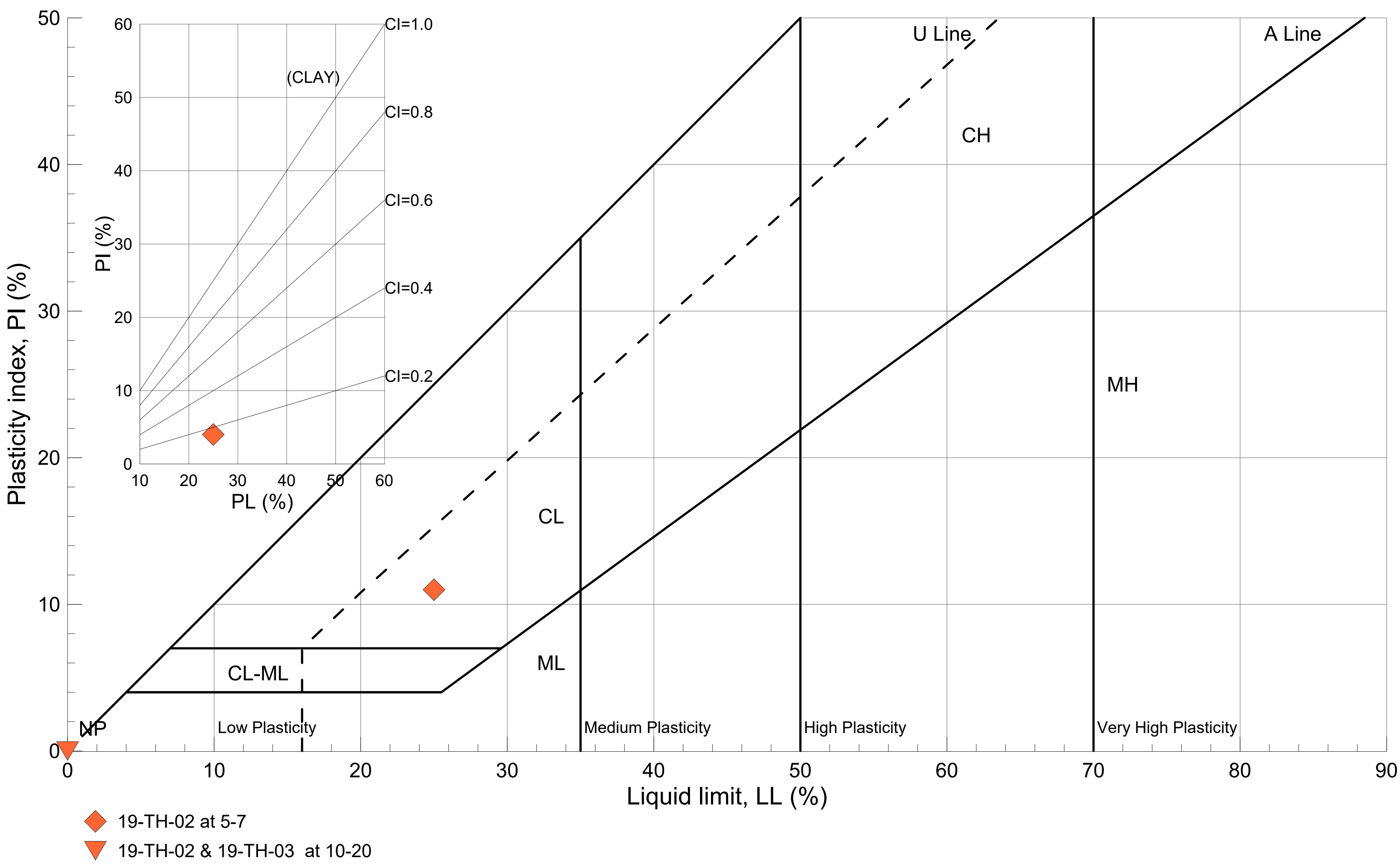
Appendix B

GERHART COLE

Jordan Valley Water Treatment Plant Upgrades
Laboratory Test Results

Project No.: 19-1225

Table of Contents



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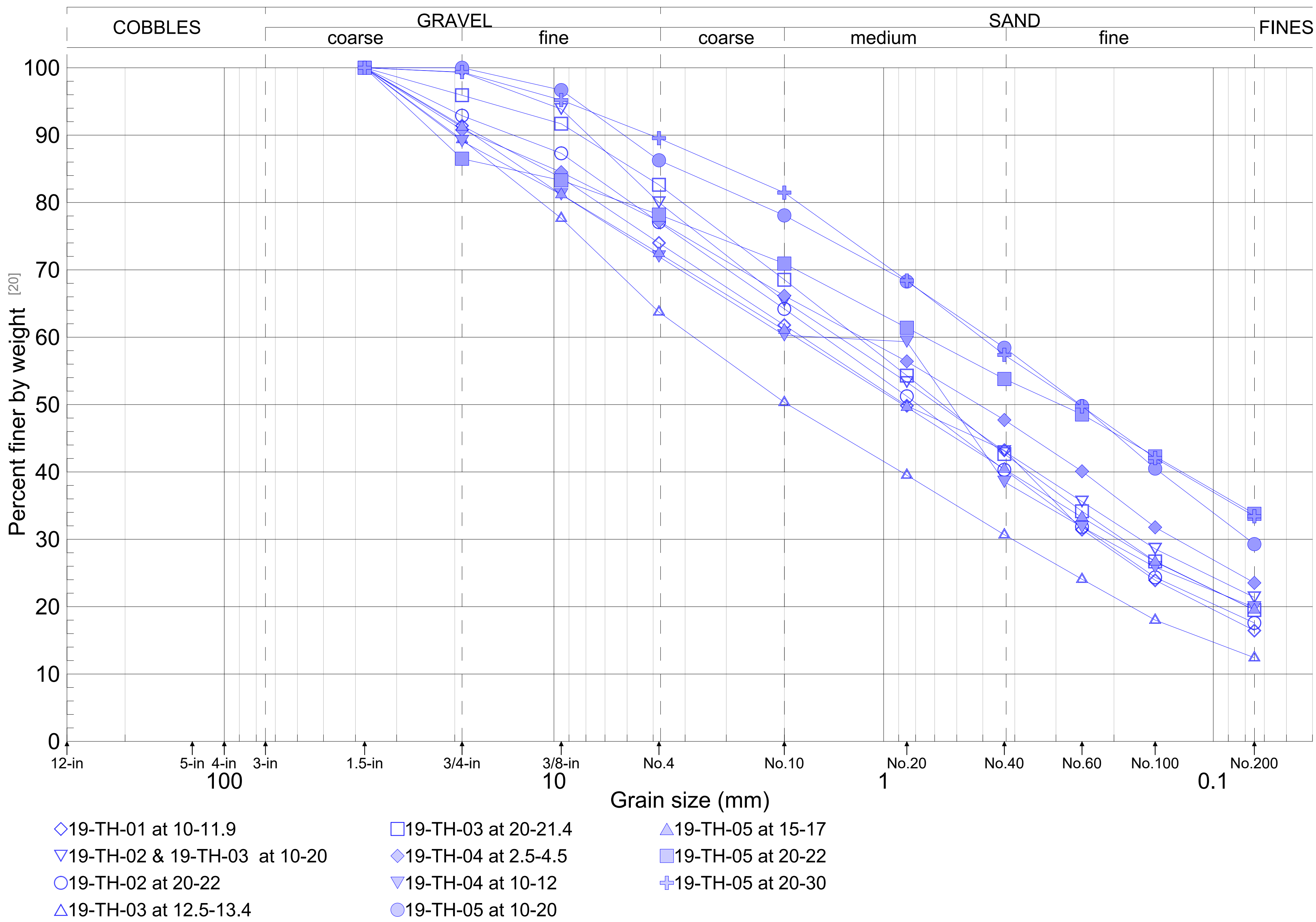
Casagrande's Plasticity Chart (Atterberg Limits)

Jordan Valley Water Treatment Plant Upgrades

B-01



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Grain-Size Analysis

Jordan Valley Water Treatment Plant Upgrades

B-02

Laboratory Compaction Characteristics of Soil

after ASTM D698 / D1557

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Project: JVWCD Bluffdale Treatment Plant Upgrades
TH/TP/Sample: 19-TH-02 & 19-TH-03
No: 19-1225
Depth: 10-20 ft
Date: 13-Jan-20
Location: Salt Lake County, UT
Tested by: YH
Comments: 19-TH-02 @ 10-20 ft and 19-TH-03 @ 10-20 ft were blended
Reduced by: YH
Reviewed by: zmg

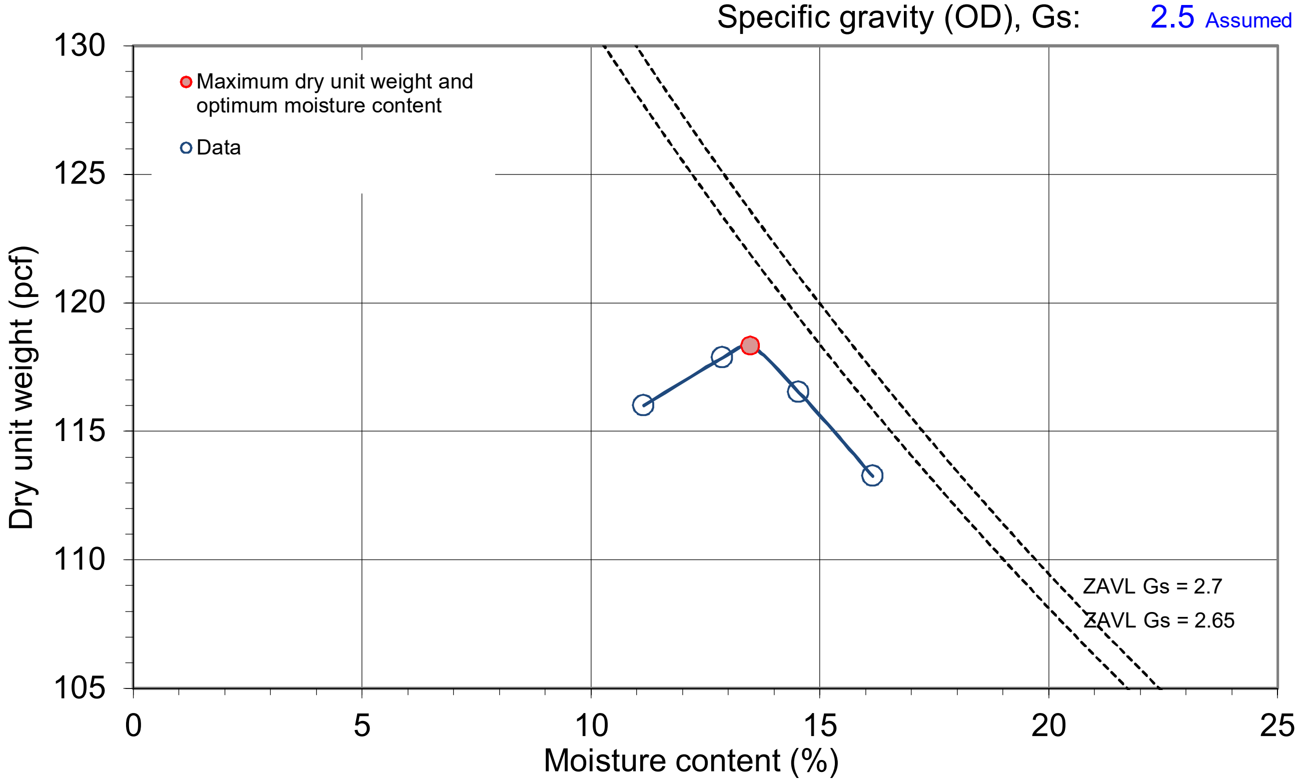
Test Summary

Laboratory sample description: Brown - dk. Brown
Method: ASTM D698 B
Engineering Classification: Not requested
Mold volume (ft^3): 0.0333
As-received moisture content (%): Not requested
Preparation method: Moist
Optimum moisture content (%): 13.5
Rammer: Manual
Maximum dry unit weight (pcf): 118.3
Rock Correction: Yes

Point Number	as-is	+2	+4	+6
Wt. mold + wet soil (g)	6195.05	6256.95	6263.30	6234.55
Wt. mold (g)	4245.40	4245.40	4245.40	4245.40
Moist unit wt., gd (pcf)	128.9	133.0	133.5	131.6
Wet soil + tare (g)	770.32	781.09	489.97	655.60
Dry soil + tare (g)	707.69	711.71	442.61	582.09
Tare (g)	146.35	172.98	117.08	127.16
Moisture content, w (%)	11.2	12.9	14.5	16.2
Dry unit wt., gd (pcf)	116.0	117.9	116.5	113.3

***Correction of Unit Weight and Water Content for Soils Containing Oversize Particles**
(ASTM D4718)

Oversized fraction, +3/8-in. (%): 6.1
Corrected moisture content (%): 12.9
Moisture content, +3/8-in. (%): 3.9
Corrected dry unit weight (pcf): 120.1
Sieve for oversized fraction: 3/8-in.
Specific gravity (OD), Gs: 2.5 Assumed



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California Bearing Ratio

(After ASTM D 1883 and AASHTO T193)

GERHART COLE

Project: JVWCD Bluffdale Treament Plant Upgrades
No: 19-1225
Date: 16-Jan-20
Tested by: yh
Reduced by: yh
Reviewed by: zmg

TH/TP/Sample: 19-TH-02 & TH-03
Depth: 10-20 ft
Location: Salt Lake County, UT

Comments: 19-TH-02 @ 10-20 ft and 19-TH-03 @ 10-20 ft were blended

Test Summary

Maximum dry unit weight (pcf):	118.3	Reference method:	ASTM D698 B
Optimum moisture content (%):	13.5	Eng. classification:	Not requested
Relative compaction (%):	99.8	Condition of sample:	Soaked
Corrected CBR at 0.1-in. (%)	**13.7**	Scalp and replace:	No
Corrected CBR at 0.2-in. (%)	**18.2**		

Compaction Data

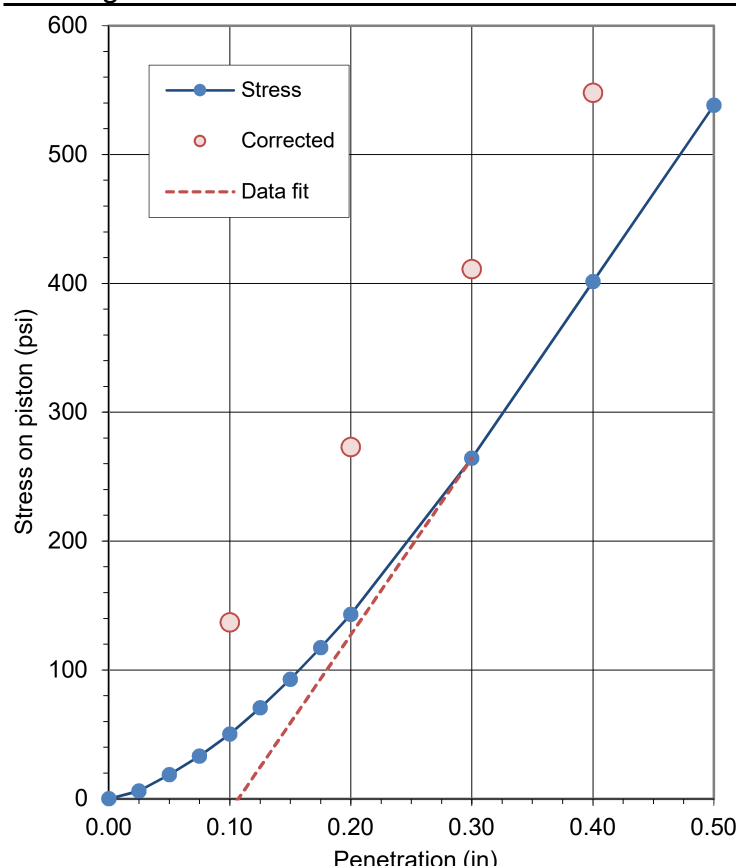
	As-Comp.	After Soak	Top 1-in.
Wt. mold + moist soil (g)	8852.75	8852.30	
Wt. mold (g)	4308.45	4308.45	
Mold volume (ft^3)	0.0750	0.0749	
Moist unit wt., gm (pcf)	133.577	133.739	
Moist soil + tare (g)	261.49	552.11	925.98
Dry soil + tare (g)	251.18	502.90	834.97
Tare (g)	173.00	125.95	145.41
Moisture content, w (%)	13.2	13.1	13.2
Dry unit wt., gd (pcf)	118.0	118.3	

Swell Data

Date	Time	Dial (in)
1/17	10:24	0.194
1/21	10:15	0.188

Soaking Period (hr)	96
Ho (in)	4.584
Hf (in)	4.578
Swell (%)	-0.13
Surcharge (psf)	50

Bearing Test Results



Penetration (in)	Meas. Stress (psi)	Corrected Str. (psi)	Standard Stress (psi)	Bearing Ratios
0	0	26		
0.025	6	61		
0.05	19	80		
0.075	33	107		
0.1	50	137	1000	13.7
0.125	71	166	1125	14.7
0.15	93	198	1250	15.8
0.175	117	227	1375	16.5
0.2	143	273	1500	18.2
0.3	264	411	1900	21.6
0.4	401	548	2300	23.8
0.5	538		2600	

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GERHART COLE

Appendix C

Jordan Valley Water Treatment Plant Upgrades
Geophysical Survey Report
Project No.: 19-1225
Table of Contents

SAGE EARTH SCIENCE
GEOPHYSICAL SURVEYS

January 15, 2020 Gerhart Cole 2020-01015 (Vs100 JV Water)

RE: In-situ shear wave velocity test V_{S100}
Jordan Valley Water
Average V_{S100} = 1,826 fps

Based on the project objective and site conditions, Sage Earth Science conducted a shear wave velocity test at the northern Utah site. The objective of the test is to determine the average shear wave velocity profile of the near surface $V_{S30/100}$ for the purpose of determining the seismic site class.

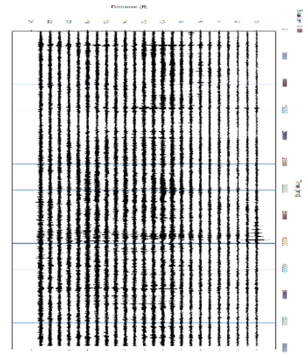


Figure 1. Field record (1 of 30 60 second recordings – total 30 minutes)

Seismic Velocity Survey

Seismic Surface Waves methods such as MASW (Multichannel Analysis of Surface Waves), MAM (Microtremor Array Measurements), and ReMi (Refraction Microtremor) use the dispersive characteristics of surface waves to determine the variation of the seismic shear wave velocity with depth. Velocity data are derived by analyzing seismic surface waves generated by a controlled impulse or by random ambient sources and received by an array of geophones.

A dispersion curve is calculated from the data that shows the phase velocity of the surface wave as a function of frequency or wavelength. A shear wave velocity profile (a 1-D sounding of velocity as a function of depth) is then modeled from the dispersion curve and the shear velocity of the near surface is calculated.

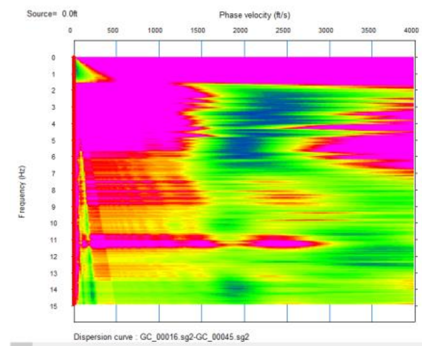


Figure 2 Phase vs. velocity plot (microtremor array measurement/MAM)

Both active source sledge hammer (MASW) and ambient micotremmor data (MAM) were acquired. Results to a significantly greater depth were achieved using the microtremor data. However, the reduced MAM near surface coverage, short wave legnth, near surface information is benefited by supplimenting active source MASW data to enhance the near surface coverage.

Table 1 Test recording parameters (MAM)

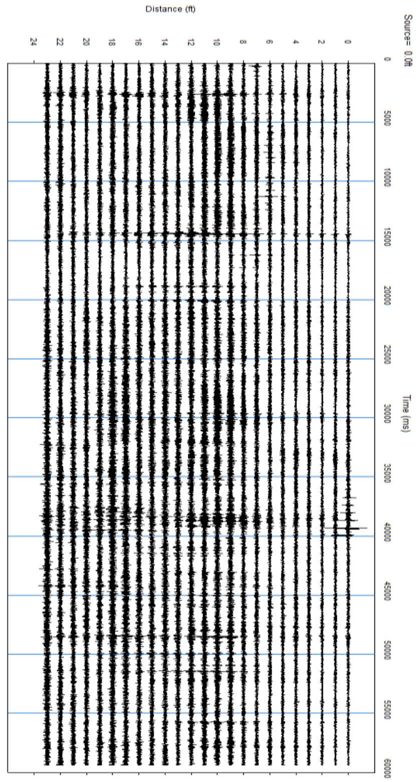
Test location	Bluffdale, UT
Recording instrument	Summit Extreme Pro
S/N	SUX1018
geophone natural period	4.5 Hz.
geophone/station spacing	16.4 ft. (5 meters)
number of channels	24
spread length	377 ft.
sample rate	4 milliseconds
number of samples	15,000 per channel
record length	60 seconds
total recording time	30 minutes
low pass filter	½ nyquist
low cut filter	1 Hz.
seismic source	passive, microtremor array measurement - MAM
source location	NA
Analysis software	SurfSeis™ Geometrics, Inc.

2184 Channing Way, Suite 110, Idaho Falls, ID 83404
telephone: (208)522-5049, Fax: (208)528-6200, email: sageearthscience@yahoo.com
http://www.sageearthscience.com

Table 2 Test recording parameters (MASW)

Test location	Bluffdale, UT
Recording instrument	Summit Extreme Pro
S/N	SUX1018
geophone natural period	4.5 Hz.
geophone/station spacing	16.4 ft. (5 meters)
number of channels	24
spread length	377 ft.
sample rate	0.5 milliseconds
number of samples	4,000 per channel
record length	2.0 seconds
total recording time	na
low pass filter	½ nyquist
low cut filter	1 Hz.
seismic source	16 lb. hammer
source location	30 feet off end
Analysis software	SurfSeis™ Geometrics, Inc.

Figure 3. Test location, Bluffdale, UT



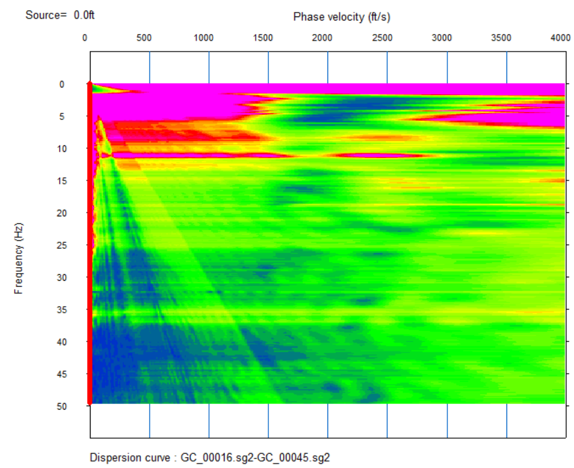
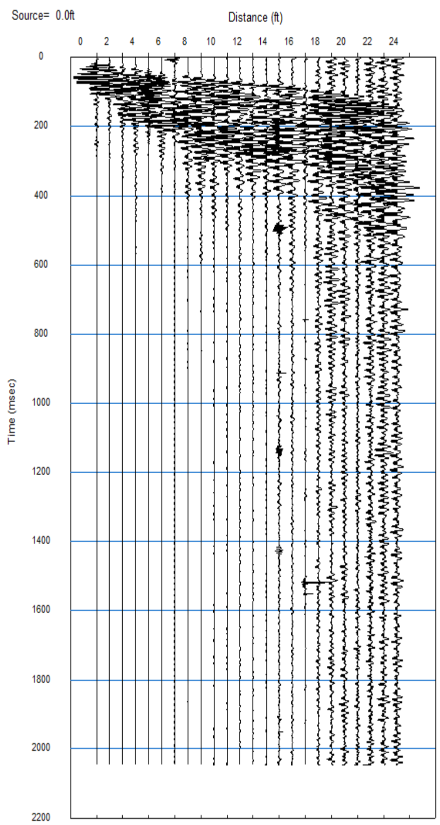


Figure 4a. Ambient field record (MAM) Figure 4b. phase velocity plot ambient data (MAM)



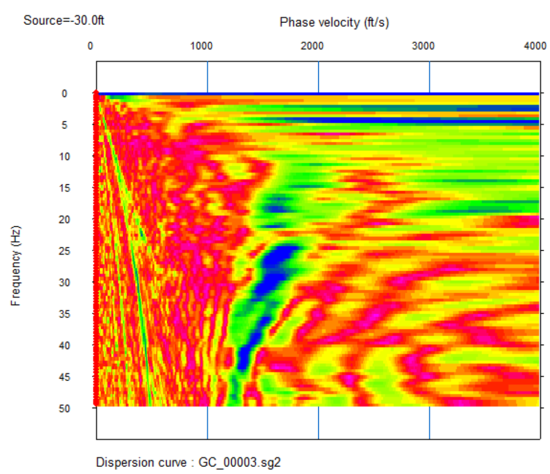
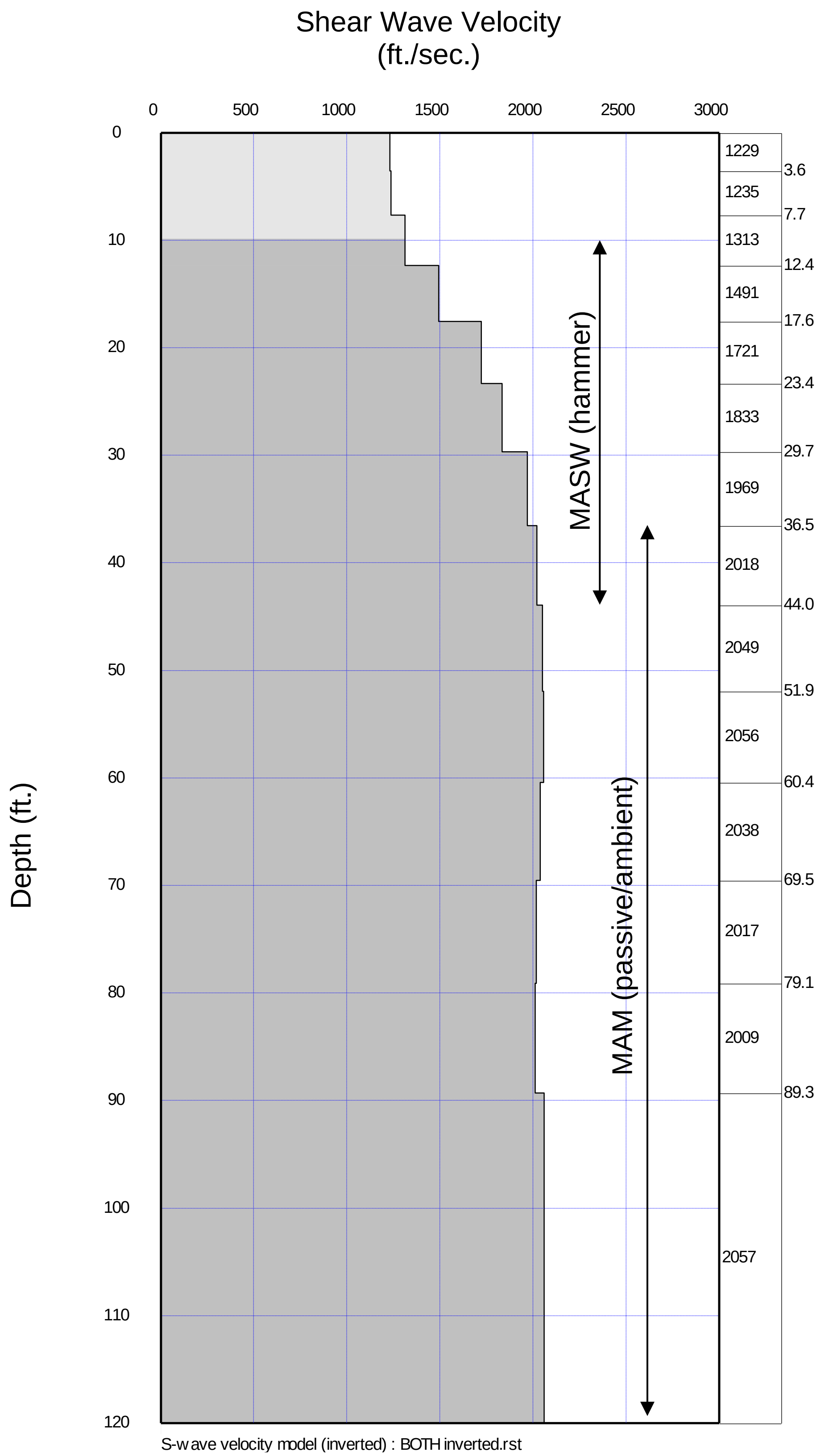


Figure 5a. MASW (hammer) field record Figure 5b. phase velocity plot MASW (hammer)



Average V_{S100} = 1,826 ft/sec